AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

# Frequency and Time Error Monitoring – 3rd Quarter 2018

**April 2019**

For the National Electricity Market

## PURPOSE

AEMO has prepared this document to provide information about the frequency and time error performance in the National Electricity Market Mainland and Tasmania regions for the period July to September 2018 inclusive.

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# Contents



# Tables

# Figures

# 1. Introduction

AEMO must use reasonable endeavours to maintain power system frequency and time error within the limits specified by the Reliability Panel in the Frequency Operating Standards (FOS)[1] for the mainland and Tasmanian regions. This document reports on the frequency and time error performance observed during July, August and September 2018 in all regions of the National Electricity Market (NEM). Queensland, New South Wales, Victoria and South Australia are referred to as the 'mainland' throughout the report.

The Power System Frequency and Time Deviation Monitoring Report – Reference Guide[2] outlines the calculation procedure used by AEMO to produce the quarterly Frequency and Time Error Monitoring report.

The analysis of the delivery of Slow Raise, Slow Lower, Delayed Raise and Delayed Lower Frequency Controlled Ancillary Services (FCAS) presented in this report are based on 4-second SCADA information derived from AEMO's systems. Unless otherwise noted, frequency data for the mainland is sourced from 4-second measurements in New South Wales and frequency data for Tasmania is sourced from 4-second measurements in Tasmania.

[1] https://www.aemc.gov.au/australias-energy-market/market-legislation/electricity-guidelines-and-standards/frequency-0

[2] http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Frequency-and-time-error-monitoring

# 2. Operation within the Normal Operating Frequency Band

Clause A.1.2(b) of the FOS requires that in the absence of a contingency event, AEMO should maintain system frequency within the applicable normal operating frequency excursion band, and should not exceed the applicable normal operating frequency band for more than five minutes on any occasion and not for more than 1% of the time over any 30 day period[3].

Frequency performance in the mainland met this requirement for Quarter 3 2018.

Frequency performance in Tasmania did not meet this requirement for Quarter 3 2018.

AEMO calculates the percentage of time spent inside the NOFB on a daily rolling average. The minimum of these 30-day averages observed within each month is reported in Figure 1. The figure shows statistics both including and excluding data during contingency events.

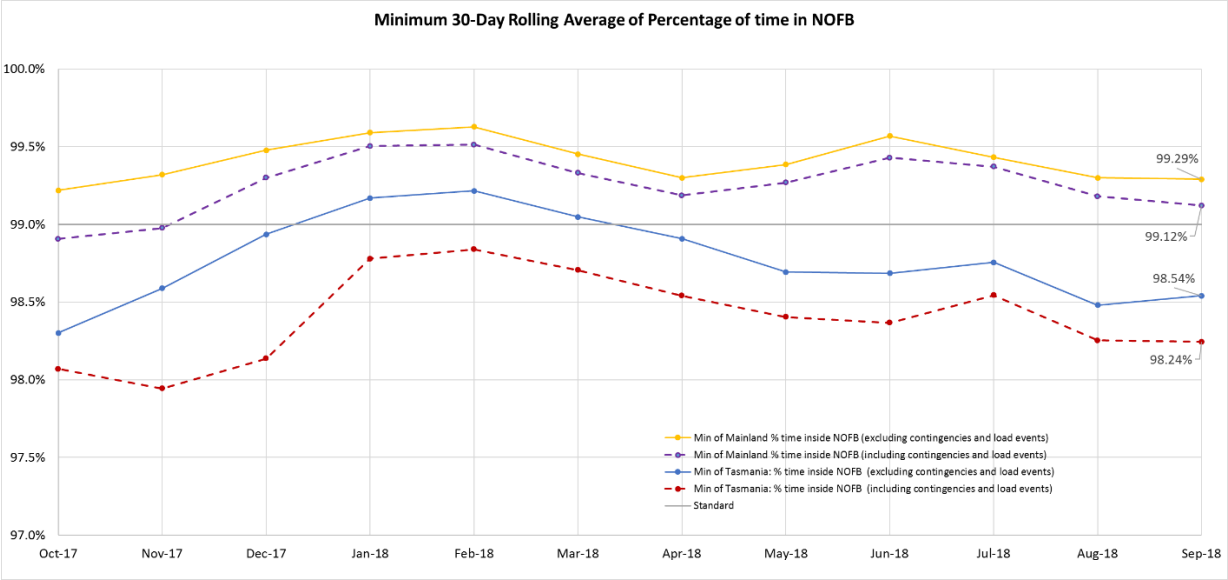


**Figure 1 Minimum 30-Day rolling average of percentage of time mainland and Tasmania frequencies remained within NOFB from October 2017 to September 2018**

The frequency distribution over Quarter 3 2018 is shown in Figure 2 and Figure 3.

[3] https://www.aemc.gov.au/sites/default/files/content/c2716a96-e099-441d-9e46-8ac05d36f5a7/REL0065-The-Frequency-Operating-Standard-stage-one-final-for-publi.pdf

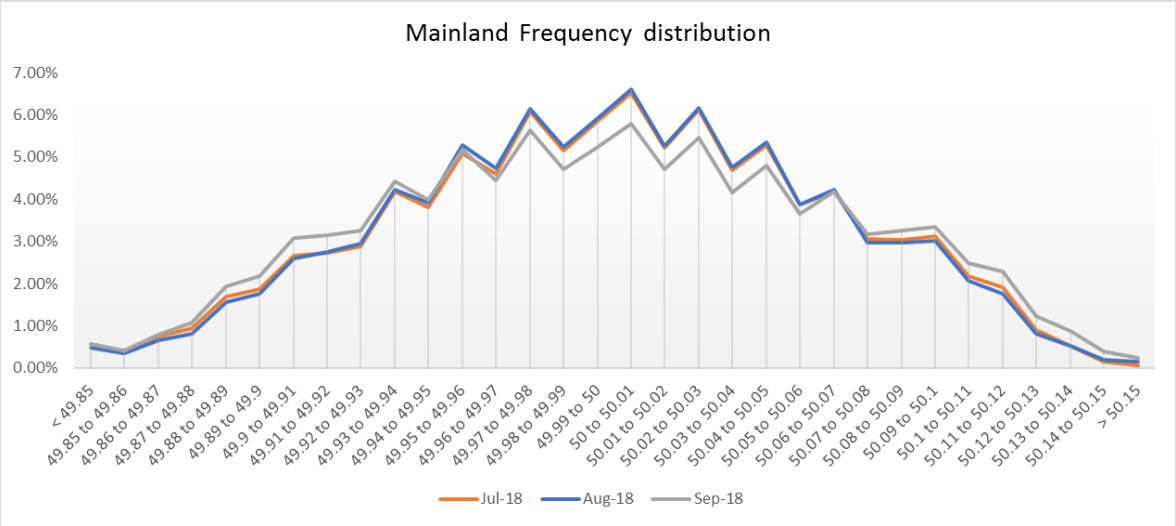


**Figure 2 Mainland frequency distribution**

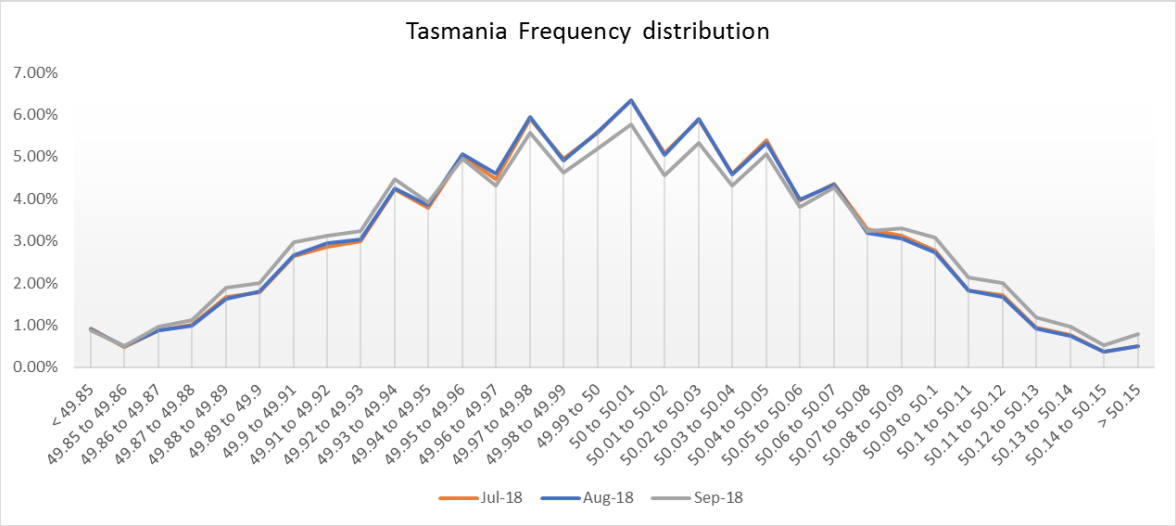


**Figure 3 Tasmania frequency distribution**

# 3. Events outside the Normal Operating Frequency Excursion Band

Table 1 and Table 2 summarise the events in the mainland and Tasmania with frequency excursions outside the Normal Operating Frequency Excursion Band (NOFEB) [4].

For all mainland and Tasmania events listed in 0, frequency returned to the NOFB within the times specified in the FOS. For the events in Table 2, it did not. These events are discussed further in Section 4.

**Table 1 Mainland and Tasmania: Frequency excursions outside the NOFEB and returned in FOS timeframes**

| Event | Low/High/Both Frequency Event | Number of Events | |
|---|---|---|---|
| | | Mainland | Tasmania |
| No contingency or load event noted | LOW | 0 | 17 |
| | HIGH | 0 | 36 |
| | BOTH | 0 | 1 |
| Load Event | LOW | 1 | 27 |
| | HIGH | 0 | 102 |
| | BOTH | 0 | 24 |
| Generation Event | LOW | 5 | 15 |
| | HIGH | 0 | 3 |
| | BOTH | 0 | 0 |
| Network Event | LOW | 0 | 0 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 0 |

[4] Frequency range of 49.75 Hz – 50.25 Hz

| Event | Low/High/Both Frequency Event | Number of Events | |
|---|---|---|---|
| | | Mainland | Tasmania |
| Separation Event | LOW | 0 | 0 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 0 |
| Multiple Contingency Event | LOW | 0 | 0 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 0 |

**Table 2 Mainland and Tasmania: Frequency excursions outside the NOFEB not returned in FOS timeframes**

| Event | Low/High/Both Frequency Event | Number of Events | |
|---|---|---|---|
| | | Mainland | Tasmania |
| No contingency or load event noted | LOW | 0 | 6 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 1 |
| Load Event | LOW | 0 | 1 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 2 |
| Generation Event | LOW | 1 | 3 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 0 |
| Network Event | LOW | 0 | 0 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 0 |

| Event | Low/High/Both Frequency Event | Number of Events | |
|---|---|---|---|
| | | Mainland | Tasmania |
| **Separation Event** | LOW | 0 | 0 |
| | HIGH | 0 | 0 |
| | BOTH | 1 | 0 |
| **Multiple Contingency Event** | LOW | 0 | 0 |
| | HIGH | 0 | 0 |
| | BOTH | 0 | 0 |

# 4. Events Outside the Frequency Operating Standards

This section analyses the events identified as not meeting the standards in the FOS.

## 4.1 Mainland Events

Twenty-two frequency events were recorded in the mainland that did not meet the FOS during this reporting period. This occurred due to the event duration, or where the frequency was outside the NOFEB for a reason other than a contingency event or a load event. For most situations, the FOS requires that frequency should not remain outside the NOFB for more than 300 seconds. Mainland frequency events exceeding FOS restoration timeframes are listed in Table 3.

**Table 3 Mainland frequency events outside the FOS**

| Event | Number of Events | Min/Max Mainland Frequency (Hz) | Duration outside NOFB - 49.85 – 50.15 Hz (sec) for min/max frequency |
|---|---|---|---|
| Generation Events | 5 | 49.67 | 372 |
| Load events | 2 | 50.16 | 316 |
| No contingency or load event | 14 | 49.75<br>50.16 | 380 |
| Separation Event | 1 | 49.01<br>50.67 | 816[5] |

Following the generation and load events, the frequency was contained between 49.5Hz to 50.5Hz but was not stable within the NOFB in less than or equal to 5 minutes.

On 16 occasions when there were no reported contingency or load events, the frequency exceeded the NOFB but was not stable and did not recover within 5 minutes. However, the frequency was always contained within the NOFEB.

More information on power system incidents causing large frequency deviations can be found in Table 4:

[5] Time outside NOFB observed in Queensland following the QNI trip

**Table 4 Power system incidents causing frequency deviations**

| Event Date and Time | Min Frequency (Hz) | Max Frequency (Hz) | Cause for the Event | Time outside NOFB (s) |
|---|---|---|---|---|
| Monday 13th August 2018 2043 hrs | MAIN: 49.65 Hz<br>TAS: 48.78 Hz | N/A | Loy Yang A2 trip | 200 |
| Saturday 25th August 2018 1311 hrs | NSW/VIC: 49.02 Hz<br>QLD: 49.75 Hz<br>SA: 49.20 Hz<br>TAS: 48.74 | NSW/VIC: 50.12 Hz<br>QLD: 50.87 Hz<br>SA: 50.46 Hz<br>TAS: 50.20 Hz | NSW-QLD interconnector (QNI) trip | 816[5] |
| Thusday 6th September 2018 0202 hrs | MAIN: 49.67 Hz<br>TAS: 48.96 Hz | N/A | Loy Yang A1 trip | 192 |
| Thusday 6th September 2018 1244 hrs | MAIN: 49.64 Hz<br>TAS: 48.63 Hz | N/A | Loy Yang A1 trip | 184 |

### 4.1.1 NSW-QLD interconnector trip on the 25th August 2018

On the 25th August 2018, the QNI interconnector between QLD and NSW tripped due to lightning. Immediately prior to the trip 857 MW was flowing south into NSW. 8 seconds after the QNI trip, the Heywood interconnector between SA and VIC opened, due to action of a control scheme. Immediately prior to the event, 165 MW was flowing east into VIC.

While no large generation unit disconnected as a result of this incident, the combined loss of supply for the VIC-NSW island was 1022 MW.

This incident resulted in a total of 1100.5 MW of load disconnection; 741.5 MW in NSW via UFLS, 278 MW in VIC via UFLS and 81 MW in TAS via contracted control scheme action.

Figure 4 below shows the frequency observed in each region during the event. This figure is from the Preliminary report - Queensland and South Australia system separation on 25 August 2018 report[6].

[6] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2018/Preliminary-report-Qld-SA-System-Separation-25-August-2018.pdf

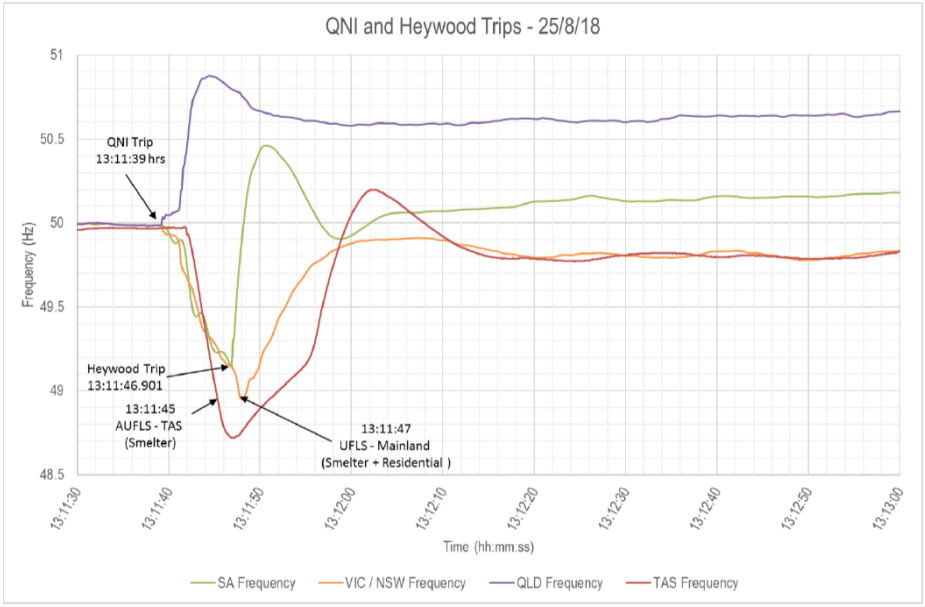


**Figure 4 Regional frequency during the separation events on the 25th August 2018**

## 4.2 Tasmanian Events

Sixty-four frequency events were recorded in Tasmania that did not meet FOS restoration requirements occurred during this reporting period. These events are listed in Table 5.

**Table 5 Tasmania frequency events outside the FOS**

| Event | Number of Events | Min/Max Tasmanian Frequency (Hz) | Duration outside NOFB - 49.85 – 50.15 Hz (sec) for min/max frequency |
|---|---|---|---|
| Frequency outside the NOFEB for reason other than a contingency event or a load event | 64 | 48.94<br>50.86 | 176 |

Following the generator and load events, the frequency was contained between 48.0Hz to 52.0Hz and recovered within the FOS timeframe of 10 minutes.

On 64 occasions when there were no reported contingency or load events, the frequency exceeded the NOFEB. Out of the 64 occasions, there were 8 cases when the frequency was not stable and did not recover within 5 minutes.

### 4.2.1 Basslink operation on the 13th August 2018

There was a power system incident on Monday 13th August 2018 that was initiated by the trip of Loy Yang A2. As a result of the outage, the frequency in Mainland dropped to 49.65 Hz. Basslink responded rapidly and the frequency in Tasmania dropped to 48.78 Hz, which is below the trigger level (48.8 Hz) of the AUFLS2 scheme. As a consequence, the AUFLS2 scheme caused 100 MW of load shedding to occur at Nyrstar. The Basslink control scheme operated as expected, with Basslink supplying frequency support above its normal market rating of 480 MW for a brief period.

# 5. Accumulated Time Error

The FOS specify that the accumulated time error should be maintained within the range ±15 seconds in the mainland and Tasmania. Constraint equations used to control mainland accumulated time error by varying the amount of Regulation FCAS enabled, are based on measurements taken in Queensland and New South Wales. The ranges of accumulated time error recorded for measurements in mainland and Tasmania are provided in Table 6.

**Table 6 Maximum and Minimum time error measurements for mainland and Tasmania**

| Value | Mainland | Tasmania |
|---|---|---|
| Highest positive time error (seconds) | 14.72 | 7.91 |
| Lowest negative time error (seconds) | -4.93 | -17.04 |

Figure 5 and 6 below show the percentage of time that the time error has been less than or greater than 1.5 seconds and the Area Control Error Regulation was increased accordingly due to the time error constraint being active.

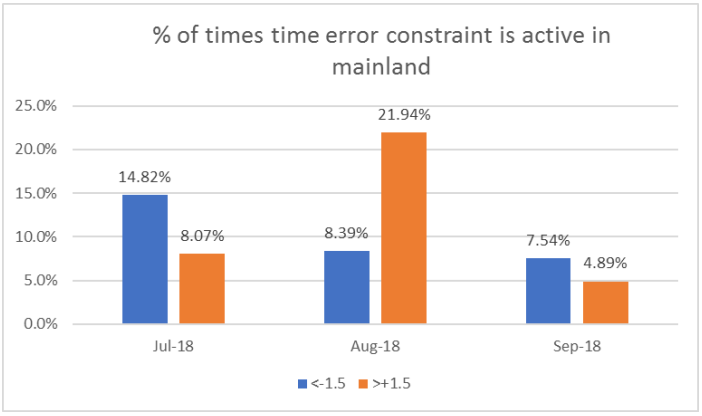


**Figure 5 Time error constraint active in Mainland**

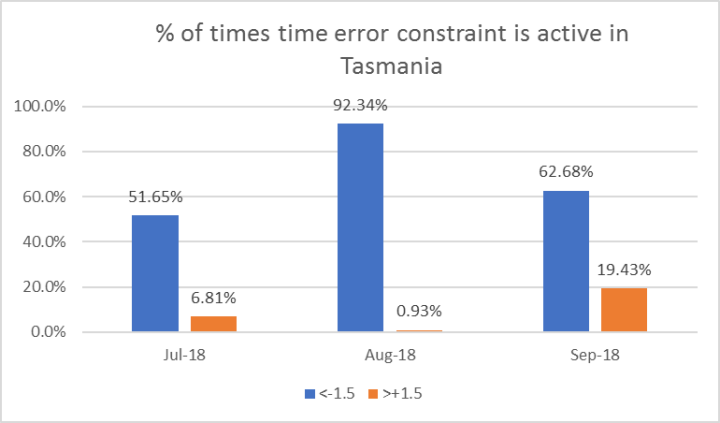


**Figure 6 Time error constraint active in Tasmania**

# 6. Area Control Error

As per the Regulation FCAS Contribution Factors Procedure[7], AEMO first calculates an area control error (ACE), representing the MW equivalent size of the current frequency deviation and accumulated frequency deviation (time error) of the system.

EQ. 1 $$ACE = 10 \cdot Bias \cdot (F - FS - FO)$$

Where:

(i) Bias is the area frequency bias and is a tuned value that represents the conversion ratio between MW and 0.1Hz of frequency deviation;

(ii) F is the current measured system frequency;

(iii) FS is the scheduled frequency (50.0Hz); and

(iv) FO is a frequency offset representing accumulated frequency deviation, i.e. time error.

Figure 7 and 8 show a comparison of the minimum and maximum ACE per dispatch intervals in the mainland and Tasmania in the last quarter.

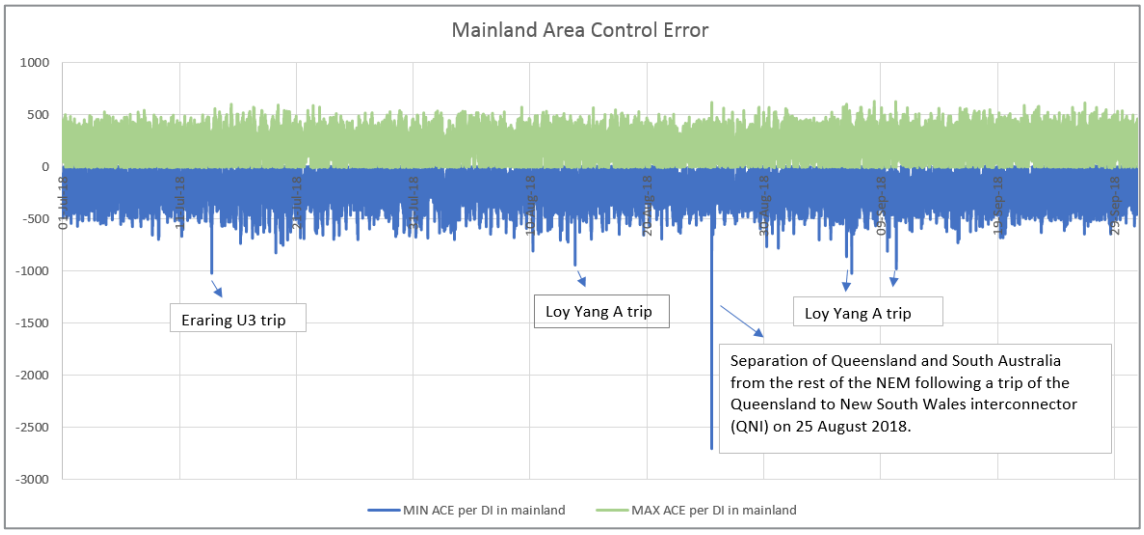


**Figure 7 Minimum and maximum ACE per DI in mainland**

[7] http://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/Regulation-FCAS-Contribution-Factors-Procedure.pdf

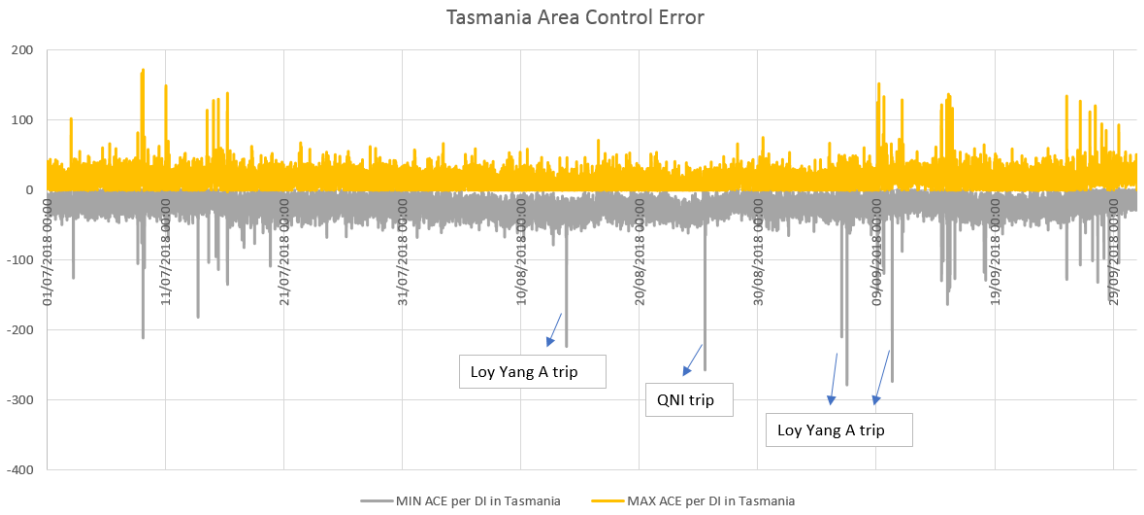


**Figure 8 Minimum and maximum ACE per DI in Tasmania**